Appearance of Dibaryon Condensates in Neutron Star Matter

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Since Jaffe proposed that there exists perhaps a stable dihyperon [1], a quest for this particle started which is still ongoing. If the H dibaryon exists, it will have certain impact on the properties of dense matter. It is quite established nowadays, that neutron stars have a large hyperon fraction in the core and are more accurately described as giant hypernuclei [2]. H-dibaryon has zero spin and will be a bose condensate if it appears in dense matter. Recently, studies for neutron stars have been done for nuclear matter without hyperons but including a possible onset of H dibaryon condensation [3].

Here, we study the influence of H dibaryons on the composition and structure of neutron stars including the hyperon degree of freedom. We use the standard extended Walecka model and the H-boson is coupled to the mean-fields by a minimal (Yukawa-type) coupling scheme. The value of the coupling constants of the H to the scalar and vector fields, $g_{\sigma H}$ and $g_{\omega H}$, are in principle unknown. The simple quark counting rule suggests that $g_{\omega H}/g_{\omega N} = 4/3$ as the H has four light quarks. The H potential in the medium, at $\rho_0 = 0.15$ fm^{-3}, then fixes the scalar coupling constant.

Figure 1 shows the composition of neutron star matter as a function of the radius of a neutron star. Hyperons appear around $(2-3)\rho_0$. The condensation of H dibaryons happens at $3\rho_0$ and the fraction of H dibaryons in the matter reaches higher values than for the hyperons. The presence of the H dibaryon suppresses the hyperon fraction and the core of the neutron star consists of nucleons and condensed H dibaryons mainly. Note, that this is the case already for a moderate attractive potential of the H dibaryon in matter which is the same as for hyperons.

The H dibaryon as a bose condensate with zero momentum will soften the equation of state considerably as it does not contribute directly to the pressure. Nevertheless, our calculations show that the maximum mass of neutron stars is only slightly changed compared to the case with hyperons and without the H dibaryon. Nevertheless, a rather low effective energy in dense matter can be ruled out as this would result in a too low maximum mass inconsistent with present observations.

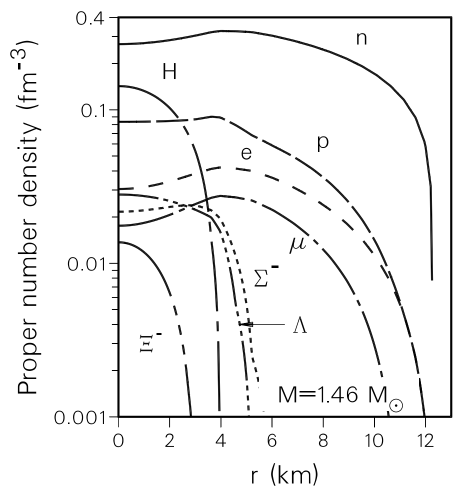

Figure 1: The composition of a neutron star with hyperons but with an H dibaryon condensate with $U_H = -30$ MeV.

References

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